BIOLOGICAL INVESTIGATION
and
FISHERIES MANAGEMENT
at
LAC LA RONGE, SASKATCHEWAN

D. S. Rawson and F. M. Atton

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LAC LA RONGE, SASKATCHEWAN

by

D. S. RAWSON

Department of Biology, University of Saskatchewan and
Biological Consultant, Fisheries Branch, Department of Natural Resources

and

F. M. ATTON

Biologist, Fisheries Branch, Department of Natural Resources

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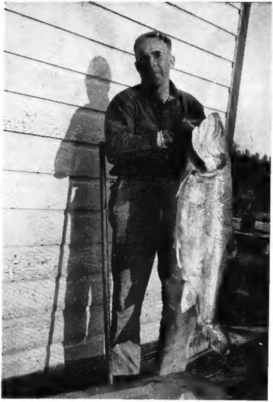
DEPARTMENT OF NATURAL RESOURCES
PROVINCE OF SASKATCHEWAN



A lake trout weighing $34\frac{1}{2}$ pounds, caught by Dr. W. M. Russell of Bremerton, Washington, at Lac la Ronge, June, 1950.

Contents

Introduction

Lac la Ronge, the fourth largest of the lakes of Saskatchewan, presents fisheries problems of unusual interest and importance. For at least 30 years it supported a commercial fishery but, after the completion of the highway to the lake in 1947, angling developed rapidly until its value now greatly exceeds that of the commercial fishery. Under these circumstances, it was necessary to determine first whether, or to what extent, game and commercial fisheries are compatible on this lake, and then to obtain information and develop techniques which would make possible maximum utilization of the fish population without prejudice to the continued production. From a handful of fishermen in 1947, anglers came in increasing numbers until in the summer of 1952 at least 6,200 fished the lake. In 1951 the returns from tourist business in the La Ronge area was reliably estimated as exceeding $400,000 (Brown, 1952), and much heavier traffic was observed in 1952. Since excellent angling was recognized as the prime attraction and mainstay of the tourist business at Lac la Ronge, it was evident that an effective management program to conserve the fish resources was most urgent.

A plan for the proper utilization of the fish in Lac la Ronge involved the collection of a variety of information. It was necessary to know what kinds and quantities of fish were present in the lake, how and where they reproduced and how fast they grew. The basic supply of fish food had to be sampled throughout the lake in order to estimate its carrying capacity for fish. Physical and chemical conditions affect the growth, feeding and movements of fish and are thus important in limiting fish production. Having obtained evidence of the basic capacity of the lake to produce fish this information was applied in a plan for utilization. This involved setting up of quotas for angling and commercial fish, the setting and adjustment of legal limits to protect the stock and especially the use of an intensive creel census by means of which the rate of exploitation and the effectiveness of regulations could be followed.

Lac la Ronge in the Churchill Valley was a type of lake not previously subject to scientific investigation. We had studied biological conditions and fisheries problems in lakes such as those of the Prince Albert Park and others further south on the soil-covered areas of Saskatchewan. Attention had also been given to some lakes such as Reindeer and Wollaston which lie entirely on the rocky Canadian Shield. Lac la Ronge lying across the margin of the shield exhibited some characteristics of each of these groups and was thus of special interest. The results of study on Lac la Ronge will be of great value and importance in solving the fisheries problems of the many other lakes which lie east and west of it in the Churchill Valley.

Plan and Progress of the Investigation

The field work was begun in May, 1948, and continued into September with a crew of three under the direction of the senior author. The program included sounding the lake, temperature determinations and other physical and chemical studies of the water, at a number of stations and periodically throughout the summer. Biological sampling included the taking of plankton (microscopic plants and animals throughout the water),

Figure 1. The NAMAYCUS, a sturdy, 28-foot fishing boat used for biological investigations on the lake.

dredging bottom samples for fish food organisms and extensive netting and examination of all kinds of fish. Data and samples from this field work were analyzed at the laboratory of the University of Saskatchewan during the winter. Effective work on this large lake was made possible by the use of a 28-foot, gasoline-powered boat, the *Namaycus* (Figure 1).

In the summer of 1949 the investigation was continued with a party of four including the junior author. The field work was similar to that of 1948 and extended into more distant parts of the lake. Special emphasis was placed on sampling the fish population to determine densities, rates of growth and food of the various species.

In 1950 the work was directed jointly with the junior author taking special responsibility for the creel census and fish tagging programs. These activities were made necessary by greatly increased angling. The basic sampling of bottom fauna and fish was completed and the results analyzed in a technical report.

In 1951 the lake work was carried on by a crew of two with occasional participation of both authors. Emphasis was placed on the creel census and tagging and netting to follow movements of fish. An additional research worker, Mr. J. Shapiro, carried on intensive work on the plankton with the assistance of a grant from the National Research Council of Canada.

In 1952 the creel census was continued, also tagging studies and special examination of temperatures and water movements. Mr. D. R. Oliver made a special study of the bottom organisms with financial assistance from the National Research Council of Canada.

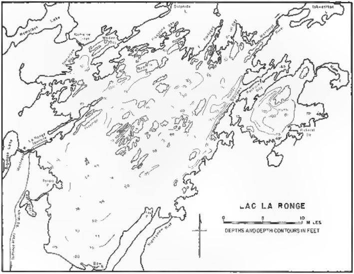


Figure 2. Map of Lac La Ronge showing depth contours in feet and localities mentioned in the text

Acknowledgements

The authors are greatly indebted to other members of the staff of the Saskatchewan Department of Natural Resources and especially the local field officers O. Linton and W. Riese who assisted in many ways with the field work and organization of the investigation. Special thanks are due to the various resort operators and to the anglers who co-operated so generously in the creel census. Much credit is due to the nine student assistants who assisted ably with the field work during the five-year period.

The Geographic Situation

Lac la Ronge lies in the centre of Saskatchewan a short distance south of the Churchill River. It is reached by road, 180 miles north from Prince Albert, by way of the Prince Albert National Park and Montreal Lake. A large part of the lake and its surrounding territory is within the boundaries of the Lac la Ronge Provincial Park. However, this does not include the La Ronge townsite and the adjacent portion of the lake.

The location of the lake across the southern margin of the Canadian Shield is responsible for the existence of some 600 islands in its northern portion (Map, Figure 2). The ancient granitic gneisses and schists of the Precambrian appear in quite rugged contours in the northern part of the lake and slope down gradually toward the south where they are overlain by Palaeozoic deposits. The south margin of the lake is characterized by glacial drift with infrequent outcroppings of limestone. Copper, gold and uranium have been located in formations along the north and east margins of the lake. Interest in uranium deposits is just now (1952) attracting developments on a scale which may affect the management of the fish resources of the lake.

The main inflow to the lake is from the south, through the Montreal River which passes through Egg and Bigstone Lakes to enter Lac la Ronge just west of the townsite. A second stream of considerable size, the Nipekamew River, enters the lake near Fox Point on the southeast shore. A few small streams to the south and west drain areas of glacial drift and carry a considerable load of dissolved minerals into the lake. The lake also receives run-off from the rocky Precambrian area along its northern and eastern margins. Most of these streams are short and small. The largest is Nemeiben Creek which drains a chain of lakes into the northwest corner of Lac la Ronge.

A lake depends on its inflowing streams for minerals which are needed for the growth of minute plants on which in turn the animals of the lake must subsist. Evidence is presented in another paper (Rawson, 1951) to show that the mineral content of the water of Lac la Ronge has varied greatly over a period of years. This would be the result of changes in the relative amounts of inflow from the Montreal River, which brings water rich in minerals, from the Prince Albert Park lakes, and from streams close to the lake which bring in water poor in minerals from the hard rocks of the Precambrian part of the watershed.

The outlet of Lac la Ronge is also considered as part of the Montreal River. It leaves the northeast extremity of the lake. A short and rapid stream runs into Iskwatikan Lake, from whence the outflow reaches the Churchill River over Nistowiak Falls about 10 miles northeast of Lac la Ronge.

The elevation of Lac la Ronge is recorded as 1,250 feet above sea level but the actual water level has varied about 5.5 feet in recent years. The average annual water levels over a 20-year period are shown in Figure 3. The variation appears to have been cyclic with a maximum 3 feet above the average in the years 1934 and 1935 and a minimum 2.5 feet below the average in 1941 and 1942. The present level is slightly above the long-term average. It is of interest that the previous maximum, in 1934-35, occurred when the prairie area was suffering a severe drought, while the minimum in 1941-42 corresponds to a period when precipitation and run-off was generally normal or above average. Our period of investigation is too short to reveal any correlation between water levels and fish production. It is known, however, that changes in the water levels of other lakes have altered or cut off spawning areas of certain fish (Rawson, 1948). Species such as the pike, which spawns in shallow marshy bays are particularly susceptible to falling water levels. It might be added that knowledge of the range of variation in water level of Lac la Ronge is of vital interest to resort operators and cottage builders.

The forest cover of the La Ronge area is typical northern coniferous such as is found on much of the Canadian Shield, dominated by white and black spruce and with jackpine on the drier soils. South and west of the lake is a low, swampy region with muskeg and black spruce vegetation. Most of the southern area draining into the lake through the Montreal River lies in the mixed wood section where well-developed stands of poplar alternate with areas of white spruce and on the lower ground, black spruce and muskeg. Most of the area has been burned over, the forest cover representing various stages of recovery. Vegetation has, of course, a stabilizing influence on the run-off and thus on the reception of mineral nutrients by the lake. The numerous and well-forested islands in the northern part of the lake have an important effect on the circulation of water and thus on the temperature and chemical conditions in this part of the lake.

Morphometry of the Lake

Lac la Ronge has a water area of 500 square miles and encloses islands which amount to an additional 50 square miles, Figure 2. Hunter Bay with an area of 50 square miles is connected to the main lake by a narrow neck about 150 yards wide. The lake is thus made up of three natural divisions, an open and somewhat shallower area to the south of about 160 square miles, the northern islands area with 290 square miles of water and Hunter Bay the deepest region, 50 square miles in area. As might be expected, these regions differ also in their biological characteristics. The lake is somewhat triangular, the north side being about 30 miles in length, the west side 25 and the southeast 35 miles. The highly irregular shoreline, measured from a map two miles to the inch, is about 650 miles. This does not include the shoreline of the islands which is also important in

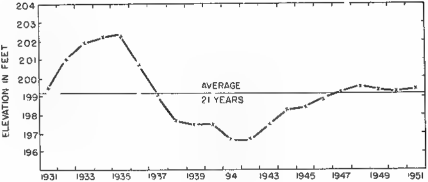


Figure 3. Graph showing the variations in the water level of *Lac la Ronge* over a 21-year period.

providing shelter and rich feeding grounds for certain species of fish. In fact, the islands and the tremendous area of shallow water which they create may be one of the main factors in the production of game fish in Lac la Ronge.

The depths of various parts of the lake were tested by about 700 soundings. From this information depth contours were drawn at 25, 50 and 75 feet, as shown in Figure 2. For convenience, a few additional depths have been inserted between the contour lines. Depths in Lac la Ronge are of unusual interest to the angler because of the habit of the lake trout of seeking great depths at certain seasons. The map shows that the southern, open water section is shallow and has a fairly uniform bottom. Its maximum depth is 72 feet and its average has been calculated as 36 feet. The islands area is deeper: maximum 124 and average 46 feet. It has a very irregular bottom with numerous reefs and deep holes. Hunter Bay has a maximum depth of 138 feet and an average of 68. The main lake being large and of moderate depth, tends to have a gradually sloping basin. Hunter Bay being smaller yet deeper, has a basin which drops off quickly into deep water.

The volume of the lake is of some importance in relation to the rates of inflow, outflow and rate of evaporation at the surface. All of these and the concentration of minerals in water entering the lake, affect the rate of accumulation of nutritive materials within the basin. The volume of the lake is known to be in the order of 25,000 million cubic yards. Rates of inflow and outflow have not been adequately measured. However, the outflow of the lake was measured on March 24, 1929 as 700 cubic feet per second. If this represents the average rate of outflow it would require approximately 30 years for the volume of water now held in the lake to pass through the outlet.

Physical and Chemical Conditions

A lake so large and varied as Lac la Ronge presents a great variety of living conditions. It was therefore necessary to establish a number of representative stations at which physical and chemical conditions could be observed. These stations were visited at intervals of a week to ten days to follow the changes which occur throughout the season. Station I is just a mile from the townsite at a depth of 36 feet and in an area somewhat affected by the inflow from the Montreal River. Station II is 4 miles out and at a depth of 52 feet. Station III, depth 69 feet, is centrally located to represent the wide open southern part of the lake. Station V northeast of Nut Point, at a depth of 102 feet, is among the islands and in one of the depressions into which lake trout congregate at midsummer. Station A is centrally placed in Hunter Bay at a depth of 126 feet. Additional stations have been established for special projects but continued observations at Stations II, III, V and A provide a general picture of the physical and chemical situation. Details of the 5 years of observation have been presented in technical reports. In the present paper it will be sufficient to illustrate some of the more important conditions with selected data.

Figure 4. The bathythermograph, a new instrument for the rapid measurement of water temperature at all depths.

The ice cover usually forms on Lac la Ronge about November 20 and the break up occurs about the third week of May. This leaves an open water period of about six months. Surface temperatures rise from about 46°F at the end of May to 65° in late July and early August. The maximum at midsummer rarely exceeds 69° in the main lake and 66° in Hunter Bay.

The lake water becomes thoroughly mixed soon after the ice goes out but the sun soon warms the surface water and wind-caused currents mix this warm water down into the lake. Thus there arises an upper warm layer, the epilimnion, which is separated from the deep cold water, hypolimnion, by an intermediate zone of rapid change in temperature called the thermocline. Temperatures at all depths are taken conveniently with the bathythermograph illustrated in Figure 4. The origin and progress of this condition of thermal stratification is illustrated in the graph, Figure 5. The curve for May 31 shows an almost uniform vertical temperature with slight warming in the upper 8 feet. By June 24 the upper 30 feet of water had been warmed to 55°F but the deep water was still between 46° and 48°. As the season progressed the thermal layering became more pronounced until, usually in late August, the surface begins to cool and eventually winds are able to mix the lake again in what is called the autumn turn over. This condition of complete mixing is shown in the curve for October 14. It persists until the ice forms in late November. It will be shown later that the progressive warming of the upper layer forces the trout down and concentrates them in a few deep areas which are therefore the fishing grounds for this species in midsummer.

The general course of heating and cooling described above occurs in every year. However, the time for particular events and the degree of thermal stratification varies considerably from year to year, and to a lesser extent from one part of the lake to another. Hunter Bay has a less extreme stratification and a much larger volume of cold deep water than the main lake. Its average temperature is usually about 3°F colder than that of similar depths at Station V in the main lake.

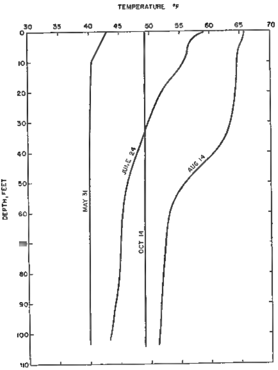


Figure 5. Selected temperature curves to show the seasonal changes in water temperature at a station near Nut Point.

Transparency and Colour

The penetration of light into the lake is vital for the microscopic green plants which form the primary food supply for aquatic animals including fish. Light penetration is measured by the depths to which a white 8-inch disc can be seen when lowered into the water. In Lac la Ronge the average of this measurement is 15 feet and in Hunter Bay 20 feet. The transparency of Lac la Ronge resembles that of Waskesiu and other highly productive (eutrophic) lakes. Hunter Bay is somewhat intermediate between this and the greater transparencies found in large, deep and less productive (oligotrophic) lakes.

The water of Hunter Bay is colourless while that of Lac la Ronge has a slight, but measurable, yellow colour no doubt originating in streams which drain from muskegs into the lake.

Dissolved Oxygen

Of the many chemical tests which are made on lake water, that for dissolved oxygen is often the most significant. In lakes such as La Ronge the oxygen supply of the deep water is replenished in spring and fall by the mixing down of surface water saturated with oxygen. When thermal stratification shuts off the deep water its oxygen begins a decline which in some lakes continues until fish are unable to inhabit the deeper regions. In Lac la Ronge oxygen depletion in the deep water at midsummer varies from year to year. In some seasons it goes down to 2.5 or 3 c.c. per litre, which, although not sufficient to kill fish, is enough to cause the lake trout to move up out of the deep cold water, which they prefer, into moderate depths where temperatures are not so low but oxygen is more plentiful. This was known to occur at Station VI in Lac la Ronge in 1949 and was suspected in at least one other season. In Hunter Bay, which has a greater store of oxygen in its deep cold waters, the lowest quantity of oxygen was rarely below 4 c.c. per litre and thus not sufficient to bring about movements of trout. The dissolved oxygen of surface water is of course constantly renewed. In Lac la Ronge it usually varies from 5 to 8 c.c. per litre, depending on the temperature.

Other Chemical Conditions

The mineral content of the lake water has been mentioned above in referring to the importance of the drainage area in supplying basic nutrient materials for plant growth in the lake. In Lac la Ronge the mineral content is now about 130 p.p.m. This is made up largely of bicarbonate 91 p.p.m., calcium 18 p.p.m. and lesser quantities of magnesium, sodium, sulphate, silica and chloride in decreasing order. This is a fairly soft water, not unlike that of Waskesiu Lake higher up in the same drainage. Hunter Bay had only 112 p.p.m. of total solids, reflecting its drainage off relatively insoluble precambrian rocks. The water in La Ronge is slightly alkaline with pH varying from 7.2 to 8.4. That of Hunter Bay is nearly neutral, pH 7.0 at the surface and slightly acid, pH about 6.7 at the bottom.

Figure 6. A large plankton net made of silk bolting-cloth, 30,000 meshes to the square inch, used to strain the microscopic plants and animals from the lake water

Plankton

The algae, microscopic plants live throughout the lake and especially in the upper 50 feet of water where light is available to help them build up primary food materials. The algae are eaten by minute animals and both provide the food for all small fish and a few adult fish such as the tullibee which have gill rakers suitable for collecting the plankton. Measurements of the crop of plankton are thus of value in estimating the fish producing capacity of the lake.

Plankton samples were taken at each of the stations listed above at each of the weekly or 10-day visits at which physical and chemical observations were made. Various instruments were used to sample the plankton but the main one was a large net of silk with 30,000 meshes to the square inch (Figure 6). By hauling this at a known rate from bottom to surface and having determined its straining efficiency, it was possible to determine the amount of plankton in a vertical column of water and to express this crop per unit area of surface. The samples were preserved for microscopic study and later determination of dry weight and organic content in the laboratory.

A large amount of material, collected in the period 1948 to 1951, has been analyzed by Mr. J. Shapiro (1952) so that we now have excellent data on the amounts of plankton in various parts of Lac la Ronge, also on the seasonal and annual variations in these amounts. The average standing crop of net plankton in the main lake during the summer period for four years was 56 pounds dry weight per acre. The average crop in Hunter Bay was approximately half that of the main lake. Seasonal variations in the amount of plankton are pronounced. The winter minimum is about 10 pounds per acre. After the break up and spring turnover, the plankton begins to build up toward the full crop which persists late into the fall. Sudden and large increases in the plankton crop, called pulses, occur irregularly throughout the season, so extensive sampling is necessary to obtain a significant average. The average crop was quite similar in 1948, 1949 and 1951, however, in 1950 it was nearly 50 per cent higher than in the other three years.

The standing crop of plankton of 56 pounds per acre in Lac la Ronge is about two-thirds that of Waskesiu and smaller than that of rich lakes in the south part of the province. On the other hand, it is two or three times as great as the crop in large northern lakes on the Canadian Shield. This suggests that the basic productivity of Lac la Ronge is intermediate between these two groups of lakes. Hunter Bay is considerably lower in productivity per unit area than the main lake.

The Bottom Fauna

The small animals which inhabit the upper few inches of the bottom of the lake provide the food for several species of fish. The quantity of these animals, like that of the plankton, is used as evidence of the productive capacity of the lake. Sampling of the bottom animals is accomplished with dredges which bite into the bottom and bring up a unit area of lake bottom. A box-like Ekman dredge, with an area of 77 square inches is used

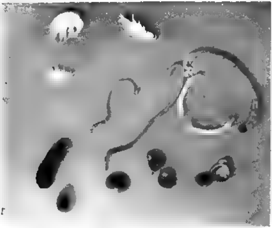


Figure 7. Typical bottom living animals which provide the food for whitefish and other bottom feeding fishes. Above left, are amphipods (freshwater shrimps) and right, chironomid (fish-fly) larvae. In the centre are aquatic earthworms and below left to right, leeches, small snails and minute clams. Photograph about twice natural size.

on soft bottom and a larger and heavier Peterson dredge on hard bottom. The bottom sample is washed through fine screens to recover the minute animals which are preserved for enumeration and weighing. In order to sample all depths and areas in Lac la Ronge a total of 570 dredgings were taken in the years 1948, 1949 and 1950.

The chief animals in the bottom fauna are the chironomid larvae and amphipods (Figure 7). The chironomids are small, non-biting flies locally called fish flies. They are dominant in the bottom population of the main lake. The amphipods are small freshwater shrimps which are very important as fish food. These animals are dominant in Hunter Bay. The approximate per cent composition of the bottom populations in the main lake and Hunter Bay are as follows:

	Main Lake	Hunter Bay
Chironomid larvae	49%	3%
Amphipods (freshwater shrimps)	17	60
Sphaeriids (minute clams)	9	25
Oligochaetes (aquatic earthworms)	17	9
Miscellaneous (snails, leeches, etc.)	8	3

Because of the great abundance of amphipods, the average number of bottom animals per unit area in Hunter Bay is much larger than that in the main lake but the weight is less. The dry weight of bottom animals in the main lake averages about 13 pounds per acre as compared to about 11 pounds in Hunter Bay.

The amount of bottom organisms in Lac la Ronge compares favourably with that of other large lakes in Western Canada. Waskesiu Lake supports about 22 pounds dry weight per acre. Lake Athabaska has about 3.6 pounds and Great Slave Lake 2.2 pounds. All of these lakes support heavy populations of whitefish which feed entirely on the bottom animals.

The Fish

Nineteen species of fish have been found in Lac la Ronge. They were taken by gill netting, seining (with drag nets) and in the examination of the stomach contents of fish. The first 10 species in the following list are large, the remaining nine are small species, never more than four inches in length and commonly referred to as "minnows".

Common whitefish	*Coregonus clupeaformis*
Lake trout	*Cristivomer namaycush*
Ciscoes (tullibee)	*Leucichthys* (two species)
Longnose sucker	*Catostomus catostomus*
White sucker	*Catostomus commersonnii*
Yellow pickerel (walleye)	*Stizostedion vitreum*
Northern pike	*Esox lucius*
Burbot (ling)	*Lota lota*
Yellow perch	*Perca flavescens*
Trout perch	*Percopsis omiscomaycus*
Ninespine stickleback	*Pungitius pungitius*
Fivespine stickleback	*Eucalia inconstans*
Spottail shiner	*Notropis hudsonius*
Blacknose shiner	*Notropis heterolepis*
Iowa darter	*Poecilichthys exilis*
Lake chub	*Couesius plumbeus*
Miller's thumb	*Cottus cognatus*
Deepwater sculpin	*Triglopsis thompsonii*

The gill nets used were in standard gangs 300 yards in length and made up of 50-yard lengths of each of 1½, 2, 3, 4, 5 and 5½ inch stretched mesh. In about 100 over-night sets of these nets the following species composition by weight was observed: Whitefish 56%, lake trout 11%, ciscoes 9%, longnose sucker 8%, pike 5%, pickerel 4% burbot 4%, white sucker 3%. Since gill nets are not equally effective in catching all species of fish these percentages should not be interpreted as an accurate indication of the composition of the population of large fish. The smaller species caught in seine hauls were mostly young perch 34%, spottail minnows 33%, ninespine sticklebacks 18%, lake chub 8%, darters 2%. The fish fauna of Lac la Ronge is composed of species which are widely distributed through the Churchill River drainage which includes the well-known lakes of the Prince Albert Park.

Figure 8. The whitefish above and the cisco or tullibee below. Note the difference between the downward opening sucker mouth of the whitefish and the pointed terminal jaws of the cisco which feeds on plankton.

THE COMMON WHITEFISH

The whitefish is the dominant species in the gill net catch and probably the most abundant in the lake. Like the white and longnose suckers, it is a bottom feeder. Analysis of the stomach contents of whitefish show that it eats mainly chironomid larvae (48%), molluscs (chiefly minute clams) (27%) and an assortment of aquatic insects and freshwater shrimp. The latter is the major food (70%) of the whitefish in Hunter Bay. The whitefish's mouth can be extended downward like that of a sucker for feeding on the bottom (Figure 8). In this respect it is quite different from the plankton feeding cisco although the two species are sometimes confused.

The rate of growth of the whitefish in Lac la Ronge has been determined by microscopic examination of the growth rings on the scales

of about seventy specimens representing all the sizes caught. The average rate of growth in length and weight is indicated in the following table:

Age in years	Length in inches	Weight in ounces	Age in years	Length in inches	Weight in pounds
2	6.3	4.0	9	15.5	1.9
3	8.0	5.5	10	16.4	2.3
4	9.5	8.5	11	17.2	2.7
5	11.2	12.0	12	18.0	3.2
6	12.4	15.5	13	18.8	3.8
7	13.6	20.0	14	19.8	4.5
8	14.5	24.5	15	20.7	5.4

This rate of growth is slower than that of whitefish in most Canadian lakes. It is even slower than that in Lake Athabaska which, being a cold northern lake, is not conducive to rapid growth. While a few specimens grew to 5 pounds in 15 years the bulk of the population is of rather small size. Our best catches were made in the 4-inch mesh net which took fish averaging 15 inches and [illegible] pounds. The slow growth and small average size of whitefish in Lac la Ronge suggest an overcrowded whitefish population which should be utilized by a vigorous commercial fishery using suitable size of mesh. This operation is now in progress as will be indicated below in the discussion of lake management.

The Lake Trout

The lake trout provides about one quarter of the weight of fish taken by anglers in Lac la Ronge, the remainder being pike and pickerel. Since the Lac la Ronge trout grow to a large size and they can be caught throughout the summer by trolling, they form a major attraction for the many anglers who visit the lake. For this reason special attention has been given to the in-

Figure 9. Fixing plastic tags at the base of the dorsal fins of trout to follow their movements in the lake.

vestigation of the trout and to the application of th. information obtained to its conservation.

The lake trout is the dominant fish-eating species of the deep water. It feeds mostly (68 per cent) on the ciscoes with smaller quantities of whitefish, 14 per cent, suckers 6 per cent, and several other species of fish including pickerel, stickleback and the young of the burbot. In Hunter Bay the small miller's thumb and deepwater sculpins are frequently found in trout stomachs. Since it feeds on the ciscoes, the trout depends indirectly on the plankton for most of its food.

Since the lake trout grows to a very large size the larger individuals are naturally of considerable age. The large size to which the lake trout may grow in Lac la Ronge makes them very desirable as trophy fish. The large specimen shown in the frontispiece was 23 years old, 40.5 inches long and weighed 34.5 pounds. It was caught in 1951. The largest trout measured in 1949 was 38 inches, 37.3 pounds, in 1950 38.5 inches 34.5 pounds and in 1952, 41 inches. 37 pounds. The rate of growth of trout in La Ronge may be indicated as follows

Age in years	Length in inches	Weight in pounds	Age in years	Length in inches	Weight in pounds
2	9.0	0.2	14	29.0	10.8
4	13.0	0.4	16	31.5	15.8
6	17.0	1.0	18	33.8	20.4
8	20.5	3.5	20	36.0	26.6
10	23.2	5.8	22	38.4	32.6
12	26.1	8.7	24	41.0	37.2

This rate of growth is faster than that of the same species in many Canadian lakes. It is nearly one third faster than the growth of trout in Great Slave Lake. Growth rate is important since the more rapid the growth rate the greater will be the annual production per unit area.

Extensive seasonal movements of lake trout have been demonstrated by netting angling and tagging (Figure 9) in Lac la Ronge. For at least two weeks after the ice breaks up the trout are widely scattered both in area and in depth. By the middle of June the upper water of the lake has warmed to about 55°F and the trout begin to move down. In July the midsummer condition of thermal stratification has developed and the upper 40 or 50 feet of the lake is all warmer than 60°F. Trout will not tolerate such warm water, and since most of Lac la Ronge is less than 65 feet in depth, they are forced to move into the few deeper areas. This concentration of the trout is most fortunate for the anglers who can troll in these areas and catch trout in Lac la Ronge during the midsummer period when in other lakes, in this latitude, trout are rarely caught. The depressions, such as those in the vicinity of Nut Point (Figure 3) and the deep water of Hunter Bay are becoming main fishing grounds and the highest average catch of trout per angler occurs in late July and early August.

When the summer temperatures reach their maximum the bottom water is cut off from circulation and, as was explained above, the dissolved oxygen near bottom is diminished. If it goes below 3 p.p.m., as it often

does in the deepest water, the trout are forced to move up and scatter into slightly warmer water, presumably because of lack of oxygen. This has occurred in late August in three of the five years of investigation. It does not occur in Hunter Bay where there is a large volume of deep water and much oxygen available.

As cooling occurs in autumn, the upper waters again reach temperatures of 50° to [illegible] and the trout again spread out in the lake. In late September they may be found in relatively shallow water and in October they come in to shallow rocky reefs to spawn. The lake trout in Lac la Ronge usually spawn between October 8 and 15. A sample of 25 spawning trout taken in October 1950, ranged from 7 to 12 years in age and weighed from 3.5 to 11.5 pounds. A single female was 22 years old, length 38.5 inches and weight 38 pounds.

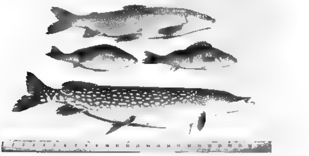


Figure 10. The northern pike below, yellow perch and the whitefish above.

Ciscoes

The ciscoes, locally known as tullibee, Figure 8, are rarely seen by the angler, yet they occupy a most important place in the economy of the lake. With their slender comb-like gill rakers they strain the microscopic food organisms (plankton) from the lake water. No other fish of any size can use this material and turn it into food for trout. The food of the ciscoes in Lac la Ronge includes from 33 to 82 per cent plankton with lesser amounts of mayfly nymphs, other insects and amphipods. In Hunter Bay the plankton provides 82 per cent of the food of ciscoes and they in turn provide 68 per cent of the food of trout. In the main lake both species take a more mixed diet but the cisco remains as the major transformer of plankton into food for large fish. In a lake such as Lac la Ronge where three piscivores, the trout, pike and pickerel are the desired crop, a commercial fishery for ciscoes would be undesirable.

The ciscoes of Lac la Ronge are probably of two species which might be called blackfin and zenithicus. Since they are difficult to distinguish, detailed studies of the two species have not yet been made.

PIKE

The northern pike, frequently called jackfish (Figure 10), provides more than half the weight of fish caught by anglers in Lac la Ronge. It is the dominant fish-eater of the shallow inshore waters and gill-net records show that it is caught in considerable numbers down to 40 or 50 feet. The pike is a voracious feeder taking ciscoes, whitefish, suckers, perch and minnows according to their availability. An analysis of 221 pike stomachs revealed ciscoes in 37 per cent, whitefish in 19 per cent, burbot in 14 per cent, pickerel in 6 per cent and suckers in 4 per cent. The remaining 18 per cent was made up of sticklebacks, minnows and crayfish. Small pike eat also moderate quantities of amphipods and aquatic insects. After midsummer the pike eat fewer ciscoes, which have moved into deeper water, and more minnows which are still available.

The pike in Lac la Ronge grows rapidly and to a large size. Thirty per cent of those taken by anglers in 1950 were larger than 26 inches and weighed more than 4 pounds. The average rate of growth of pike in this lake is indicated in the following table.

Age in years	Length in inches	Weight in pounds	Age in years	Length in inches	Weight in pounds
2	13.5	0.7	10	34.5	11.1
4	21.5	2.5	12	37.0	14.1
6	26.5	4.7	14	39.0	18.0
8	30.5	7.2	16	41.0	22.0

This rate of growth is about one-sixth faster than that determined for pike in Waskesiu Lake in 1932. It is possible, however, that the pike in Waskesiu now grow faster since heavy angling has greatly reduced their numbers. The largest pike recorded in 1951 was 46 inches long and weighed 27.7 pounds. Many pike weighing over 20 pounds are taken in Lac la Ronge each season.

The pike spawn in the middle of May in numerous marshy bays around the main shore and the islands. They are readily available for angling throughout the season and are taken in increasing numbers as the pickerel catch falls off in July and August.

YELLOW PICKEREL (WALLEYE)

The pickerel or walleye, Figure 11, inhabits the shallow water competing with the pike for food in May and June but, in the remainder of the summer, it tends to scatter into the deep water. The food of 133 pickerel was made up largely of unidentifiable fish remains. Of the identified fish, suckers, sticklebacks and ciscoes were most numerous with perch and spot tail minnows occurring less frequently. The freshwater shrimp *Gammarus*, crayfish and aquatic insect nymphs were also common in the stomachs examined.

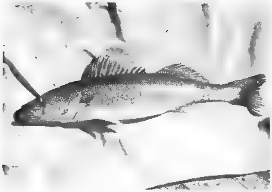


Figure 11. The pickerel or walleye, one of the three main game fish species in Lac la Ronge.

The growth rate of pickerel in Lac la Ronge has been worked out by the usual technique of measurement and scale reading. The results are summarized as follows:

Age in years	Length in inches	Weight in ounces	Age in years	Length in inches	Weight in pounds
2	7.2	2.9	8	18.8	2.2
3	9.8	6.0	9	20.0	2.6
4	12.1	10.0	10	21.5	3.2
5	13.9	14.6	11	22.8	3.8
6	15.6	20.8	12	24.0	4.6
7	17.0	26.9	13	25.1	5.8

This growth is much slower than that of its competitor the pike. The pickerel in Lac la Ronge takes more than five years to reach a weight of one pound while the pike attains this weight in two and one-half years. The pickerel of Lac la Ronge also grow somewhat slower than the same species in other areas. In Lake of the Woods they grow 15 per cent faster and in Wisconsin and Minnesota they grow faster by about 25 per cent.

Seasonal movements of the pickerel are much more extensive than those of the pike. The pickerel run into streams entering the lake at the end of April and usually spawn during the first week of May. More than 400 pickerel were tagged in the Montreal River near its entrance to the lake in early May 1951 and 1952. An unusually high percentage of recoveries was noted. Forty two per cent of the pickerel tagged in 1951 were recovered in the same year. During the first half of June most of these recoveries were from Egg Lake and other waters above the point of tagging. After June 15 and into July almost all recoveries were from the

main lake and from an area not more than three miles from the mouth of the Montreal River It is clear that, because of their spawning habit, the pickerel are particularly vulnerable to angling during May and June It would seem also that the pickerel which use a particular stream for spawning, form a population group which may not mix much with those from other parts of the lake

The anglers' catch of pickerel falls rapidly at the end of June and becomes almost negligible by the end of July Gill-net catches show that at this time they spread out into the deeper water of the lake. In June and early July the bulk of the gill-net catch of pickerel was in the upper 16 feet In August and September the largest catches were from 20 to 30 feet, and considerable numbers were taken at depths down to 65 feet.

Capacity for Fish Production

It is not yet possible to say with certainty how much fish a given body of water can produce annually Nevertheless we are gradually accumulating knowledge for this purpose and, in the interest of conservation, it is essential that we should make full use of all the pertinent

TABLE I LAC LA RONGE COMMERCIAL PRODUCTION

Fiscal year Ending March 31	Whitefish	Trout	Pickerel	Pike	Suckers	Others	Total
1922	69,300	72,200	20.900	27 700	21,700	17 700	229 500
1923	23 700	78,800	2.800	10.400	14,500	12,700	142 900
1924	53.200	91,300	6,800	8.100	10,700	7 200	177,300
1925	100.800	149,200	22,600	26.200	30,700	30.800	360,300
1926	214,200	188.000	23,000	23.600	37 200	37.000	352.000
1927	224.100	176,900	17.300	30.700	84 700	100,300	694,000
1928	336.900	184,900	22,900	20,100	27 800	25,800	618,400
1929	348.600	182 900	24.300	22,000	38.700	30.200	646,700
1930	251,900	164,600	14.300	18,100	26.500	22 500	497,900
1931	374.000	191.628	7.600	30,600	33.200	10.400	647 428
1932	78,400	36,800	1 500	1 100	7 900	6.200	131,900
1933	74,800	52,800	9,400	38,500	20.800	21.600	217,900
1934	55,526	77 520	8,836	16,530	10.330	5.400	174.142
1935	49.963	40.100	10,350	2 100	6.750	21 700	130,963
1936	47 323	34.343	1.850	3.470	9 300	16,200	112,486
1937	200,40[illegible]	128,331	35.064	11 964	50 515	24 150	450,065
1938	157,956	261.654	17 858	9,393	25.800	33 750	506,411
1939	197.270	245 558	27 115	10,350	78.975	134.715	693.983
1940	72,059	133,300	21.676	16,896	78,176	78.610	400,717
1941	nil	nil	nil	nil	nil	nil	nil
1942	3.500	400	1,000	3,500	4,000	400	12,800
1943	17.400	2,070	4,346	3 720	1,560	1,100	30,196
1944	3 740	46,039	19.913	2.709	7 495	5,890	87,786
1945	5.046	120,832	42,048	13.043	10,750	10,070	201,789
1946	58,509	110,327	69,381	4,655	30,500	5,500	278,872
1947	48,115	151.581	77 403	6,355	4,867	25,000	313,321
1948	88,460	146,835	46,76[illegible]	7,258	nil	nil	289.314
1949	34,488	59,130	53,129	2,886	9,311	nil	158,944
1950	26.812	50,089	30,916	2,346	1,330	nil	111.493
Totals	3,278,468	3,178,137	641,046	374,275	683,699	684.885	8,840,510
Average per year	117.088	113.505	22,895	13,367	24,418	24,460	315,733
Percentage	37 1	35 9	7 3	4 3	7 7	7 8	100 0

information. In the case of Lac la Ronge, we have some evidence of its productive capacity in the history of its commercial fishery. Our studies of the amounts of plankton and bottom fauna, which are the basic food supply, and of the rates of growth of fish are helpful. A comparison of the physical and biological features of Lac la Ronge with those of other lakes whose productive capacity have been demonstrated, has been made. Consideration must also be given to the selective nature of the harvest, i.e., to what extent is angling utilizing the whole production of the lake or is it overexploiting particular species?

During the 27-year period up to 1948, the average annual production of fish from Lac la Ronge was 318,000 pounds (Table I and Figure 12). This amount was made up of whitefish 37%, lake trout 36%, pickerel 7%, pike 4%, suckers 7%, tullibee and others 8%. The average take of whitefish was just 118,000 pounds but for one period of seven years an average of 275,000 pounds was taken without apparent damage to the stock. Moreover, it has been observed in other lakes producing both whitefish and trout, that the long term production of whitefish is much greater than that of trout, whereas in Lac la Ronge almost equal quantities of both were taken. For these reasons it is suspected that by increased use of whitefish the annual production of Lac la Ronge could be safely increased by at least 50 per cent over its past commercial production.

The average standing crop of plankton in Lac la Ronge was indicated above as 56 pounds dry weight per acre and the bottom fauna 13 pounds dry weight per acre. Judging by the data available for other lakes of this size and depth in temperate climates, this plankton is above average and the bottom fauna near to average in quantity. Thus the basic food supply for fish in Lac la Ronge is clearly not deficient. Moreover, as has been mentioned above, the large number of islands provide additional shore areas rich in certain kinds of fish food. The average commercial fish production in large lakes of western Canada has been shown by the senior author (Rawson, 1952) to bear a fairly constant relation to their mean depth. On this basis Lac la Ronge proper might be expected to produce about 3 pounds of fish per acre annually while Hunter Bay, which is deeper and has less plankton and bottom fauna, might be expected to produce about 2 pounds per acre.

The possible production of 3 pounds per acre assumes reasonably full utilization of the main species of fish in the lake. Angling is usually highly selective, often taking only one or a few of the species present. Thus Rounsefell (1946) shows that for lakes of similar area, those fished commercially commonly produce up to fifteen times as much as those producing only game fish. Lac la Ronge is somewhat unusual in this regard in that trout, pike and pickerel are all heavily fished by angling. The only other important species is the whitefish which should obviously be utilized commercially since, as will be shown later, this can be done without damage to the game species.

The recent anglers catch in Lac la Ronge has been 204,000 pounds in 1950, 280,000 pounds in 1951 and 251,000 in 1952. It is thus approaching the former average commercial catch of 318,000 pounds. In the winter of 1950-51, 150,000 pounds of whitefish were taken, and in 1951-52, 250,000 pounds. A catch of 318,000 pounds from Lac la Ronge is just equal to

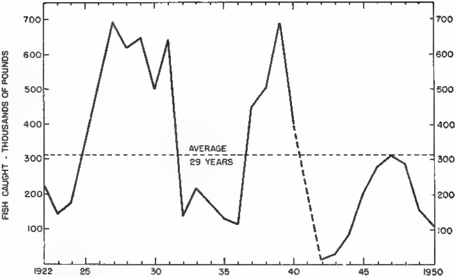


Figure 12. Variations in the commercial fish catch in Lac la Ronge over a period of 29 years.

one pound per acre of water. The present total game, domestic and commercial catch of about 600,000 pounds, is still well within the estimate of three pounds per acre, which has been suggested above as a reasonable rate. It should be emphasized that such a rate of exploitation is entirely tentative and that it will be modified at once if the program following up the effects of fishing indicates that such a change is needed.

The Creel Census

While production records have been kept for most commercial fisheries, records of angling returns are usually lacking or at best rather incomplete. Thus if the angler fails to catch fish, he is likely to assume that the waters are "fished out" and to urge planting as the remedy. The administrator in charge of angling resources may or may not agree, but neither he nor the angler have any factual basis for discussion or action. Likewise, when restrictive regulations are applied on a virgin lake, the angler may feel that this is quite unnecessary for the lake is "teeming with fish" and "anglers catch very few". Man does not attempt to manage a business without calculating his annual profit nor does he attempt to utilize any other resource with no knowledge of the annual harvest. Thus the first and absolute essential for the management of a game fish resource is a creel census. In Lac la Ronge this has been a special concern of the junior author and his carefully chosen field assistants.

Details of the program and results of creel census have been presented elsewhere in technical reports (Atton, 1951, 1952). It will suffice here to provide a general indication of the methods used and to discuss some of the more significant results.

Lac la Ronge is reached by a single highway which is therefore used by all anglers except the few who travel by air. There is only one resort on the lake, at the townsite, La Ronge, from which all angling parties set out. A large proportion of the fish taken by angling from Lac la Ronge are frozen in the government operated freezing plant and later carried home by the anglers. Because of these fortunate circumstances, a single active creel census worker can observe and record personally a large proportion of the anglers' catch. Each day the investigator visited the freezing plant, called on each outfitter who supplied boats and guides and, in addition, interviewed a large number of individual anglers. The resort operators have shown great interest and have been most co-operative in obtaining complete and accurate records. This program was carried on from the opening of the season on May 16 to the middle of September at which time the bulk of the angling was over.

The information was recorded on suitable creel census cards which listed for each species caught the fork lengths, number of hours of fishing and other pertinent information. Cards were filled out each day for each angler. One of the duties of the census taker was to prepare each week a careful estimate of the proportion of anglers whose catch was reported. This was done by checking with boat operators and others to learn of parties which had been missed, also by examining the records of camp operators and those of the freezing plant. The estimated coverage varied from 75 to 90 per cent and over the whole period averaged 82 per cent.

Table II. Summary of the results of the Creel Census in Lac la Ronge, 1950, 1951 and 1952

	1950	1951	1952	Trend
No. of Anglers	3,500	5,700	6,250	Rising
Total Catch, pounds	204,000	280,000	25[illegible],000	Rising
Composition of the catch:				
Trout	32.0%	24.0%	19.0%	Down
Pickerel	16.0%	16.5%	18.0%	Steady
Pike	52.0%	59.5%	63.0%	Rising
Catch, per acre	0.65 lbs.	0.93 lbs.	0.83 lbs.	Rising
per angler	54.4 lbs.	52.5 lbs.	40.1 lbs.	Down
	13.5 fish	11.0 fish	9.0 fish	
per hour	12.0 lbs.	13.0 lbs.	4.5 lbs.	Down
	3.0 fish	2.3 fish	1.0 fish	
Average size of fish	4.0 lbs.	4.8 lbs.	4.5 lbs.	Steady

The main results of the creel census are summarized in Table II and the reader's attention is drawn particularly to the trends indicated in the last column. The total number of anglers has increased 78 per cent from 3,500 in 1950 to 6,250 in 1952. The total catch increased from 1950 to 1951 but in 1952 dropped though it is still 4 per cent above the average annual catch. The changing composition of the catch is of greater significance. The lake trout is now contributing 13 per cent less to the creel than in 1950 thus showing a definite downward trend. The pike is increasing in importance, now providing 11 per cent more of the catch, and the pickerel has remained almost unchanged. These changes were not unexpected in view of the heavy fishing pressure on the trout population.

The average catch per acre is another expression of the above facts and emphasizes that the harvest of Lac la Ronge by anglers is substantial. Rounsefell (1946) indicates that the expected average catch of game fish from a lake the size of Lac la Ronge is 0.54 pounds per acre. Lac la Ronge has exceeded this in each of the three years recorded in Table II. The average catch per angler has declined only slightly from 13.5 fish weighing 54.4 pounds in 1950 to 11.0 fish weighing 52.5 pounds in 1951. In 1952 more stringent regulations were largely responsible for a reduction of the average catch to 9.0 fish weighing 40.1 pounds. This is still remarkably good angling. The increasing average size of fish taken might be thought to indicate better angling but there has been a deliberate selection of larger fish by the anglers so this really indicates a steady quality of angling. At the same time selection has operated to reduce the number of fish caught per angler and per hour. A third factor in 1952 which also made fish less available to the angler was an unusually cool season. The trout were not concentrated in the deep holes where the anglers usually make heavy catches. For these reasons it is thought that the quality of angling has not declined as much as the decrease in catch per hour might suggest.

In order to keep a close check on the progress of angling the creel census records are analyzed at the end of each half-month period. This reveals some interesting and important details of the seasonal progress of angling. Figure 13 shows the average poundage of fish per angler throughout the three seasons. The trend in 1950 shows an increase

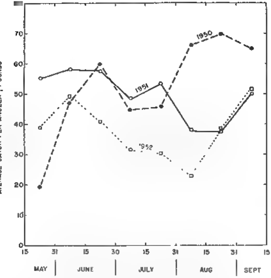


Figure 13. The average poundage of game fish caught by individual anglers in Lac la Ronge, 1950, 1951 and 1952.

throughout the season. In 1951 the trend is reversed, suggesting that the maximum had been reached. In 1952 the trend paralleled that of 1951, but is somewhat lower until late August. The reasons for this situation have been outlined above (page 32).

The variation in the number of anglers throughout the season is shown in Figure 14. The number in June is almost double that of July or August. This is largely a matter of preference (or prejudice?) on the part of the angler, for the detailed analyses show that the average catch per angler in June is only slightly greater than in July or August, and the percentage of lake trout, usually the preferred species, is usually higher in the catch for July and August than in June.

In the interpretation of the creel census records attention has been given to influences which tend to mask the effect of fishing on the fish stock. Thus in 1951 the anglers tended to spread out into areas not fished in 1950. Improved transportation to and accommodation at Hunter Bay resulted in much heavier fishing effort in that area in 1951 and 1952. The reduction of catch limits in 1951 and 1952 undoubtedly had an effect on the angler's catch as compared to that of 1950.

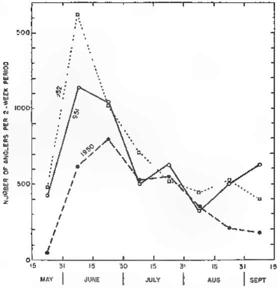


Figure 14. The average number of anglers at Lac la Ronge by two-week periods, during the summers of 1950, 1951 and 1952.

The Management Program

One of the first questions to be answered by the investigation was whether or to what extent angling and commercial fishing are compatible in Lac la Ronge. The former commercial fishery of 318,000 pounds per year is now approached in quantity by an angler's catch which the creel census shows to have averaged 244,000 pounds during the years 1950 to 1952. The monetary returns, both direct and indirect, from fish taken by anglers is many times that of the same poundage on the commercial market. Moreover, it has been shown that an extensive winter fishery for whitefish can operate without damage to the game fish population. There is thus no question that Lac la Ronge should be managed as a game fish lake and treated as such in any instance where the interests of game and commercial fisheries are in conflict.

The total annual crop of fish to be expected from Lac la Ronge has been estimated using the past history of its commercial fishery, its present physical and biological conditions and comparison with other lakes of

known productive capacity. Past evidence shows it to be capable of producing more than 300,000 pounds per year or about one pound per acre. Biological and physical evidence suggest that it should produce at least two pounds per acre or about 600,000 pounds. This would assume a selective fishery for whitefish taking perhaps 250,000 pounds of that species, an angler's catch of more than 300,000 pounds and some allowance for the substantial domestic fishery. Such an estimate is definitely tentative and should be subject to frequent review.

The commercial fishery for whitefish was recommended above in order to make best use of this resource and with the hope of relieving some of the food competition for the game species which feed to a limited extent on bottom organisms. Also, since the whitefish are small and numerous, it is possible that vigorous harvesting would result in faster growth and larger sized whitefish. This fishery should be in the late fall and winter when the netting operations do not interfere with angling and the freezing plant is free to handle the catch. It has been demonstrated that by careful control of the location of nets, very few game fish are taken. In the winter of 1950-51 the catch included nearly 15 per cent of game species. In the fall and winter of 1951-52 the catch of 225,000 pounds included only 3 per cent of game species. It should be noted that this commercial fishery does not affect the ciscoes and thus leaves the main line of trout production plankton—cisco——trout undisturbed.

The domestic fishery is a problem in the management of the lake. It is difficult to obtain satisfactory records of the amount of fish taken. It is also unfortunate that the heaviest domestic fishery is concentrated within two (or three) miles of the mouth of the Montreal River and is thus draining fish from the area closest to and heavily fished by the resort of La Ronge. Other important areas for domestic and Indian fishing are at Potato and Nemeiben Rivers. Records are available for the numbers of domestic licences and free Indian permits issued each year. The combined catch from these sources is estimated by the officer in charge as between 100,000 and 150,000 pounds per year. This is a substantial fishery and must be considered in estimating the total allowable catch as suggested above. The chief conflict between the domestic and game fisheries is in the pickerel. From 400 pickerel tagged in the Montreal River (page 27 above) 1951 and 1952, 170 were recovered; of these 148 or 87 per cent were taken in domestic nets. It would appear that about half the pickerel population in the vicinity of La Ronge was taken in the domestic nets. Since the bulk of the fish taken in domestic nets is used for dog food, it is possible that special arrangements for netting coarse fish, principally suckers, could be made to substitute for the valuable game fish. The problem is administrative rather than biological.

The conservation of the game species is the primary aim of the management program. The creel census provides information concerning the status of the various game species. Catch limits can be adjusted to help protect species which are in danger but their effectiveness is subject to certain limits. They have little effect on the number of anglers visiting the lake and the number of anglers is the main factor in determining the total catch. Ordinarily, catch limits affect only the relatively few anglers

TABLE III DAILY CATCH LIMITS OF GAME FISH FOR FOUR SEASONS IN LAC LA RONGE

	1949	1950	1951	1952
Trout	7 fish	7 fish	5 fish	4 fish
Pickerel	12 fish	12 fish	10 fish	7 fish
Pike	no limit	no limit	10 fish	10 fish

In 1952 additional limits were placed on the aggregate poundage of each species, i.e., trout, not to exceed 25 lbs. plus 1 fish, pickerel, 15 lbs. plus 1 fish, pike, 40 lbs. plus 1 fish.

who are able or wish to take the maximum allowed. Moreover if limits are drastically reduced there is a greater tendency to break the law or to discard small fish when larger ones are caught. Thus the protection of the game species requires the use of other techniques such as diversion to new areas or other species of fish, also educational activities which emphasize the angling as a sport rather than a contest to see who can get the greatest poundage. A summary of the daily limits for the years 1949 to 1952 appears in Table III.

The lake trout is the main attraction for anglers at Lac la Ronge. It is thus most important that the lake trout be protected. The total catch by anglers in 1951 showed a small decrease from 1950 (Table II) and in 1952 a further decrease occurred. Because of this situation, the daily limits for trout were reduced from 7 to 5 to 4 fish and a further restriction was placed on the poundage in 1952. The slight decline in the quality of trout angling is not surprising in view of the heavy angling pressure. However, there is at present no reason to anticipate a drastic decrease in the trout catch. It should be noted that the present annual trout catch is only 60 per cent of that taken by commercial fisheries over a long period. Thus it would appear that the lake can produce more trout if the anglers can catch them. Under the unusually favourable conditions for all summer trout fishing at Lac la Ronge, it seems probable that the anglers will be able to harvest a large part of the possible crop of trout.

The pickerel appears to be the most vulnerable of the three game species in Lac la Ronge. The heavy catch of pickerel in late May and June near the La Ronge townsite both by angling and domestic nets, would seem to be more than the local population could stand. A small reduction in the daily limit was made in 1952. Other and more distant pickerel grounds have been found which are helping maintain the present total catch of this species. At present the local run is so readily caught that it is expected to suffer some deterioration.

The pike has been indicated above as bearing the greatest weight of angling in Lac la Ronge. Not long ago it was not considered necessary to place a catch limit on this species. Lac la Ronge has a tremendous area of shallow water suitable for pike production and many marshy bays for

spawning, it has withstood increasing catches in the years 1950 to 1952 with slight increases in the catch per net and a slight increase in the average length of fish caught. This record is difficult to evaluate since anglers have been going progressively further afield to fish for pike. This species was fished only slightly, averaging 13,000 pounds per year, in the commercial fishing, so we have little data for predicting the sustained yield from the lake. Experience at Waskesiu Lake, where heavy angling greatly reduced the pike in a few years, suggests that the species may well be depleted.

The introduction of new species or planting of additional quantities of species already present, have been commonly used to support or improve game fisheries. Lac la Ronge is well supplied with suitable spawning grounds for its game species so there is no reason to consider planting any of these. The present game species provide considerable variety of angling and might well be considered satisfactory [illegible]. However there is at present very little fly fishing available in the area and there exists elsewhere in the Churchill River drainage a species which provides excellent fly fishing. This is the grayling, *Thymallus signifer* (Figure 15). The grayling thrives in northern lakes along with lake trout [illegible]. It was therefore decided that an attempt should be made to extend the range of the grayling south to Lac la Ronge. Grayling eggs have been taken in 1949, 1950, 1951 and 1952 in the [illegible] at Black Lake east of Lake Athabaska. They have been hatched in small batteries at Lac la Ronge and a total of about 933,000 fry have been released in the lake near what appeared to be suitable spawning streams. In 1952, 27,000 were reared to the fingerling stage and liberated in the lake. The results of these plantings have not yet been determined.

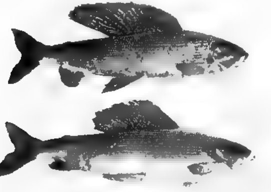


Figure 15. The grayling, a fine species for fly fishing now being planted in Lac la Ronge. Male above 2½ pounds, female below 3 pounds.

In late June of 1951 while checking for grayling at the outlet of Lac la Ronge it was discovered that common whitefish were in the river feeding on caddis. They took artificial flies and fought vigorously. Fifty whitefish were taken on three rods in a few hours fishing (Figure 16). The possibilities of this species for fly fishing are being investigated further.

Conservation and the Future

The aim of the present investigation is the conservation and wise use of the fish resources of Lac la Ronge. Can the present excellent fishing be maintained [illegible]? Man is still new at the business of [illegible] but with his growing knowledge of [illegible] the dynamics of populations it should be possible [illegible] ping. It is not to be expected that [illegible] in the past [illegible] change [illegible] in the future [illegible] such as began [illegible] Lac la Ronge in 1950 [illegible] should, however, it is possible to follow the changes [illegible] and take appropriate action.

To obtain the information needed for this [illegible] several techniques will be needed:

1. A [illegible] scale [illegible] will reveal the rate of harvesting and the availability of the game fish.

2. Catch analysis applied to fish taken by angling, commercial and domestic fishing will reveal the growth rate, average size and age composition. All these [illegible] should be watched to detect any changes in the population.

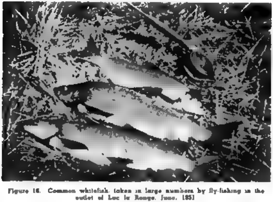


Figure 16. Common whitefish, taken in large numbers by fly-fishing in the outlet of Lac la Ronge, June, 1951

Studies of the life histories of the game fish now in progress will provide information essential in interpreting the creel census and catch analysis. Tagging studies to reveal the extent of fish movements will be particularly helpful.

After a number of years of exploitation it should be possible to reduce the amount of sampling and catch analysis needed to follow the population trends. The creel census will need to be continuous and periodic checks on growth rate should be made for the important species.

The desirability of accessory activities in the management program has been mentioned above. Anglers should be encouraged to distribute their activities over the whole lake and to expand to other lakes. Fuller utilization of local opportunities might be made, e.g., fly fishing for whitefish. If the introduction of grayling is successful, that will provide a new kind of angling and utilize an area near shore and a food supply not much used by the present game species. It should be emphasized, however, that these activities are only accessory to the main plan. The central core of management must depend on creel census, catch analysis, review and revision of regulations to control, as far as possible, the level of harvesting on a basis of long-sustained production. Looking back at the results of the creel census, one might ask where else than at Lac la Ronge can an angler catch nine game fish weighing 40 pounds in a day's fishing? That is worth preserving.

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